APPENDIX C

ROCKET BALLISTICS

Requirements for Accurate Predicted Fire

There are fire general requirements for achieving accurately predicted fire. These requirements are accurate target location and size, firing unit location, weapon and ammunition information, met information, and computational procedures. If these requirements are satisfied, the firing unit will be able to deliver accurate and timely fires.

Target Location and Size

Accurate and timely detection, identification, and location of ground targets and the determination of their size and disposition on the ground are essential for accurately computing firing data. Determiningthe appropriate time and type of attack requires that the target size (radius or other dimensions) and the direction and speed of movement be considered. Target location is primarily determined by use of target acquisition assets and sensing platforms. Other sources include maneuver FSEs and special operations forces.

Launcher Location

The PADS provides accurate survey data for survey control points used by launchers. Accurate firing point location is a function of the launcher SRP/PDS based on the initial survey data. It can also be derived at the firing point directly from GPS.

Weapon and Ammunition Information

The ballistic algorithm imbedded in the EU of the launcher FCS takes into account specific ammunition information (weight ambient temp, and ammunition type).

Solution Meteorological Information

The effects of weather on the rocket must be considered and the firing solution must compensate for those effects. Use of current meteorological information in the FCS allows the firing solution to compensate for current weather conditions (see Chapter 4 for time and space validity considerations and responsibilities regarding met verification).

Computational Procedures

The computation of firing data must be accurate. Special applications programs (SPAR) programmed in the launcher FCS yield accurate and timely firing data. Individual and collective training reduce the probability of procedural or data input error.

Rocket Error Sources

Bias Errors

Bias Errors affect all rockets of a mission. They are "occasion to occasion" errors. Example - errors in measurement of wind speed or direction, errors in measurement of air density.

Boost Wind. This is the unpredictable error between the measured wind velocity and the wind velocity that the rocket actually encountered during the initial launch stage. The MFOM rockets are extremely sensitive to the low level winds due to the relatively low velocity of the rocket as it leaves the launch tube. The resulting effect produces a path heading error in the first few seconds of flight.

Coast Wind. This is the unpredictable error between the measured wind velocity and the wind velocity that the rocket actually encountered during the majority of its flight (upper level winds).

Standard tactical meteorological system reports a measurement that is two hours old and is taken a number of kilometers away from the rocket flight path. This spatial and temporal difference is the major contributor to the random bias error associated with both boost and coast winds.

Impulse. This is the difference between the average total impulse of the rocket motors in the pod and that of the nominal motor. This error is controlled by manufacturing tolerances and system design.

Drag. This is the difference between the average aerodynamic drag of the rockets in the pod compared to the perfect nominal rocket. This error is also controlled by manufacturing tolerances and system design.

Ambient Temperature. This is the unpredictable difference between the measured temperature of the atmosphere and the actual temperature experienced by the rocket. Temperature is a variable used to compute air densities which in turn is used to compute drag.

Pressure. This is the unpredictable difference between the measured pressure of the atmosphere and the actual pressure experienced by the rocket. Pressure is also a variable used to compute air density and ultimately drag.

Position Determining System (PDS). There are errors created by the onboard position determining system. The majority of range errors are due to the inaccurate determination of launcher altitude. This error is independent of rocket design or manufacture.

Submunition. These errors are primarily due to unaccounted and unknown winds in the target area.

Rocket/Stabilization Reference Package (SRP) Misalignment. This error is due to a misalignment of the launch pod and/or rockets and the SRP. This error is controlled by system design, manufacturing tolerances, and launcher maintenance procedures.

Precision Errors

Precision errors are caused by variations between rockets. Example - variations in launch weight, variations in rocket motor total impulse (see Figure C-1).

Mal-Launch. Mal-launch is the apparently random "kick" given to the rocket while it is exiting the launch tube. It is created through a complex and not well understood interaction of the rocket with the launch pod, the sabots, launcher, and exhaust gases. Mal-launch rates are usually derived indirectly and quoted as an angular rate at tube exit and are not predictable.

Drag. Drag variability is the random rocket-to-rocket variability of the drag characteristics.

Impulse. Impulse variability is the random rocket-to-rocket variability of the rocket motor.

Submunition. This factor is caused primarily by the height of burst (HOB) precision variability. Varying HOBs will allow a variable amount of wind drift to affect the submunition secondary trajectory.

Mass Unbalance. Mass unbalance is the unbalanced condition of the rocket as it leaves the launch tube. An unbalanced condition will create a real-launch condition.

Thrust Malalignment. This is the condition where the motor thrust is not aligned with the rocket center. The effect of this has been minimized by the use of rocket rotation.

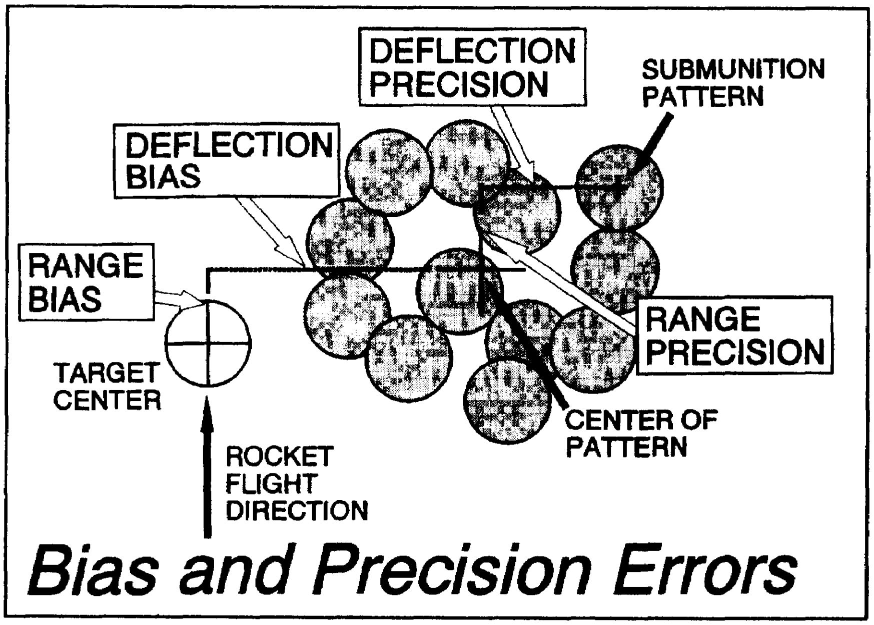

Figure C-1. Bias and precision errors.